EINLEITUNG IN DIE VERGLEICHENDE GEHIRNPHYSIOLOGIE UND VERGLEICHENDE PSYCHOLOGIE. Mit besonderer Berücksichtigung der wirbellosen Thiere. Von *Dr. Jacques Loeb*. Mit 39 Abbildungen. Leipzig: Verlag von Johann Ambrosius Barth. 1899.

Prof. Jacques Loeb has been doing sound and important work in his laboratory at the University of Chicago, and evidences of it have appeared from time to time in little monographs, some of which have been mentioned in former numbers of *The Monist*. The results of his labors are not without important consequences and appear calculated to throw new light on the vital questions of physiology, evolution, heredity, and the general principles of the natural sciences. We are therefore much pleased that he has now published the results of a great part of his labors in a condensed form in the present book, which is a continuation of the author's researches on the heliotropism of animals.

The author had shown that the heliotropism in animals is in every way identical with the heliotropism in plants. On the other hand the tropisms of animals are reflex actions or instinctive actions; for instance the flying of the moth into the light. As everybody knows, the generally accepted theory of reflex or instinctive actions takes it for granted that they are determined by specific structures in the ganglions. But this assumption became doubtful through the author's proof of the identity of animal and plant tropisms. Hence it was necessary to investigate whether the ganglionic theory of reflexes is not after all an arbitrary, unnecessary or even false assumption. The author contributes a number of facts which show that the reflexes are determined by the arrangement of the muscles or the contractile elements on the one hand and the sense organs or the irritable structures in the skin of the animal on the other, and that the central nervous system only acts as a protoplasmic conductor for the transmission of stimuli from the sense-organs to the muscles.

Among the proofs for this the following may be mentioned. In ascidians the whole central nervous system consists of one single ganglion which can easily be removed, but these animals differ from higher forms in that the stimuli can be transmitted directly from element to element of the body without the interference of the central nervous system. These organisms possess a typical reflex and if one touches them they close their openings and contract. The author found that the same reflex continues after the removal of the central nervous system. Hence this reflex cannot be determined by hypothetical specific structures in the ganglion, but must be determined by the arrangement of the muscles of the animal.

The author further shows that in higher animals matters are not different. The closing of the pupil under the influence of light is considered a typical reflex action in which the stimulus is carried through the optic nerve to the central nervous system and from here back through the oculo-motor nerve to the iris. Specific structures which determine these peculiar reflexes are considered to be located in the ganglia or centers for the reflex. Yet it has been known for a long time that in an excised

eye the same reflex action still occurs under the influence of light. In this case, of course, the light causes directly the contraction of the muscles of the iris. Hence this peculiar reflex is determined not by hypothetical structures in the ganglionic cells but by the arrangement of the muscular fibres of the iris. Another example is offered by the reflex of the bladder and the anus. It has been shown by Goltz and Ewald that these reflexes continue even after the destruction of the spinal cord.

Hence it is impossible that these reflexes are due to hypothetical specific structures in the ganglion cells; they must be due to specific structures and irritabilities of the peripheral organs themselves.

While we then become convinced that the central nervous system does not contain the specific structures for the reflex organs but is acting only as a conductor, and moreover, that in some cases the reflexes continue after the ganglia or the spinal cord are extirpated, it does not as yet follow that the ganglia or the spinal cord are redundant and without consequence. In another set of experiments Professor Loeb showed what the true function of the nerves is in such cases. Ascidians can exist, both with and without nervous system, but on determining the smallest intensity that is needed to produce their specific reflexes we find that a reaction is quicker in the animal with central nervous system than in the one from which it has been removed. This fact reveals to us that the central nervous system acts as a more sensitive and accelerating conductor. An animal without central nervous system or without spinal cord may be able to show a number of reflexes and instinctive actions and adaptations, but it would not be able to adapt itself quickly to rapidly changing conditions.

What the author said in regard to ascidians also holds good for animals with a segmental nervous system. An annelid or an arthropod may be considered as a colony of segments each of which is comparable to an ascidian. Each segment has its reflexes which depend, as in the ascidian, not upon structures in each ganglion, but upon the irritabilities of the sense organs of the skin and the arrangement of muscles. The only difference is that stimulation of one of these segments not only causes an activity in the stimulated segment but in the other segments too, as the various segments are connected with each other by conductive protoplasm.

What however becomes of the leading rôle which the brain is generally assumed to play by modern authors? Professor Loeb shows that this so-called leading rôle of the brain no more exists than the hypothetical reflex structures in the ganglionic systems. In annelids, for instance, spontaneous locomotion continues even if you cut off the head of the animal. If we dissect fresh-water planarians, even pieces without brain continue to make spontaneous progressive motions. It was formerly assumed that frogs, pigeons, and dogs without cerebral hemispheres would no longer be able to show any spontaneous motions, but the experiments of Schrader and Goltz prove this to be an error.

Professor Loeb grants that there are cases in which animals no longer make progressive locomotions after the loss of the brain. For instance, decapitated sea-

water planarians and the cray-fish without brain no longer walk spontaneously. But he adds that we cannot explain why the motion stops. It would be wrong to draw the conclusion that in these animals the brain plays the leading rôle over the rest of the ganglia. For if we take out the cerebral hemispheres and thalamus opticus in a frog the animal loses its spontaneity but if we take out a little more the animal not only moves again spontaneously but moves incessantly. The same is true for the shark. Hence if in some cases we find that after the loss of the brain or part of the brain an animal loses its spontaneity this phenomenon has to be explained in a different way from that of assuming that the brain has a leading influence over the rest of the ganglia.

The same may be said in regard to the leading rôle of the brain in the co-ordination of motion. The co-ordination of motion can according to Professor Loeb be explained through the mutual influence of the various elements of an organism upon each other, and an assumption of a specific organ or ganglion of co-ordination would have to be regarded as a mere anthropomorphism. In the heart for instance the co-ordination of the variously active elements is due to the fact that that element which beats fastest forces the other elements to beat in its own rhythm.

When Friedlander cut an earth-worm in two and connected the two pieces by threads, the posterior part moved in a perfectly co-ordinated way as soon as the anterior part began to creep. But in this case the co-ordinated motions of the posterior half cannot be due to any influence of the brain, and Goltz's experiments prove that matters are not different in dogs. The reason that in some animals the loss of the anterior ganglion or the so-called brain has a greater effect than the loss of any other ganglion is that in these animals the peripheral parts of the anterior segments, i. e., the head, possess a higher differentiation with more sense organs and more tentacles than in any other segment.

This conception of the segmental character of reflexes is also true for the vertebrates, but while it is easy to prove it for invertebrates it has not as yet been recognised or positively shown to obtain in higher animals. Physiologists have a tendency to localise the seat of reflexes too high, that is say, too near the brain. Professor Loeb believes that the central nervous system is not built upon any other plan in the vertebrates than in the arthropods but that the difference is only based upon the peculiarity of the vertebrates, viz., that each operation in vertebrates is accompanied by severer shock-effects than in the anthropods. This has led to a number of misunderstandings. In the horse-shoe-crab the organs of respiration (gills) are situated at the abdomen. The segmental conception of the central nervous system demands that the nervous organs where these respiratory motions are started be situated in the abdominal part. We find, indeed, that if we destroy all the rest of the central nervous system leaving only the ganglia of the abdominal segments intact, that the respiratory motions continue after a short interruption in a perfectly normal way. The text-books however say that in vertebrates respiration is not determined by the segmental ganglia of the respiratory muscles but by

the *nœud vital* in the medulla oblongata. The argument on which their claim is based is that if we destroy this *nœud vital* respiration stops; but in this case respiration stops on account of the shock-effect which the operation produces upon the respiratory segmental ganglia. For if we take a newly-born vertebrate in which the shock-effects of the operation are considerably less severe we find that after destruction of the vital point in a medulla oblongata the respiratory motions continue and the organs for the respiratory motions therefore must be situated in the segmental ganglia of the respiratory muscles.

The segmental theory is of importance for the theory of localisation. That injury to the different parts of the cortex cerebri produces definite and different effects, is due to the fact that the fibres from the various segmental ganglia of the spinal cord in the medulla enter the cortex in different spots. Hence the so-called centres of the cortex must be simply regarded as the spots where the various sets of nerve-fibres enter the cortex. But Professor Loeb insists that it does not follow from this that these spots are the special seats of various functions; for instance, that, vision takes place only in the so-called visual sphere. It is perfectly possible or even probable that the processes underlying the psychic functions, e. g., vision, take place in the whole of the central nervous system or the whole cortex cerebri. The author offers facts obtained from Goltz and based upon the phenomena of association and interference of simultaneous innervations which would go far to prove that "the partial-soul theory" is an impossibility. The disturbances of function which follow the destruction of any of these centres of the cortex are due to a shock-effect upon the segmental ganglia with which the various centres are connected, and Professor Loeb mentions a number of experiments which would corroborate this view.

The animal tropisms form a considerable part in the complex of phenomena which constitute the subject of comparative psychology. But as animal and plant tropisms are identical we must admit that plants possess consciousness too if we call the cases of animal tropisms psychic phenomena. And further as the tropisms can be reduced to physical and chemical phenomena we would have to admit that psychic phenomena accompany every process in nature. Thus we would reach ultimately the assumption of soul-endowed molecules and atoms. Professor Loeb shrinks from this assumption. He tries to show that the conclusion of pan-psychism can be avoided by defining consciousness as a function of associative memory. This is his criterion that proves the presence of consciousness. By associative memory he understands that mechanism by which a stimulus not only produces the effects determined by the inherited structure of the organism and the character of the stimulus but also those additional effects of their stimuli which have made an impact upon the same organism simultaneously with the first stimulus. A simple example of this is that the odor of a flower, a purely chemical stimulus, reminds us of the shape and color of the flower itself. But how can we find out whether an animal possesses associative memory? If an animal can be

trained to do things upon a signal which are not necessarily determined by the physical effect of the signal it must possess associative memory (for instance if a dog turns around upon hearing its name called or if an animal is taught to look for its food upon hearing a certain sound, etc.). The application of this principle gives the result that there is no trace of memory in Cœlenterates, in Echinoderms or in worms. Among arthropods and mollusks certain forms may possess associative memory but if this is the case it has yet to be proven. It is only certain that a number of vertebrates possess associative memory and hence are capable of having consciousness. Under the influence of narcotics, in the case of fainting, in deep sleep, associative memory comes to a stand still, but at the same time consciousness disappears too. On the other hand, in such cases where the existence of consciousness has been claimed and where no trace of associative memory can be found, a closer examination shows that the assumption of consciousness was due to a mistake. An example may be mentioned. If we injure a worm and the worm wriggles, we are inclined to believe that this is an expression of a sensation of pain. In this case the criterion for the presence of consciousness is based upon the assumption that the same cause produces in a human being similar motions which are accompanied by a sensation of pain. But Professor Norman has shown that if we cut a piece out of a worm and cut this in two, only the posterior half shows this wriggling motion, and if we go on dividing pieces of worms in every case the piece behind the cut shows wriggling motions while the piece in front of the cut does not show any motions which one might interpret as being due to a sensation of pain. Hence we come to the conclusion that a piece of a worm only has sensations of pain if it is behind the place of lesion while the same piece of a worm is devoid of the sensations of pain if it is in front of the lesion, which of course would be utterly absurd. The true explanation is that a stimulus in travelling backwards throws the longitudinal muscles into activity while the stimulus in travelling forwards throws the ring muscles into activity. In the latter case co-ordinated motions occur; in the former case the wriggling motions occur, but the interpretation that the latter are an expression of pain was wrong.

There are similar instances. Professor Bethe observed that if one cuts off the abdomen of a bee while it is sucking honey this injury does not disturb the bee in the least. The author takes up other instances in which psychic phenomena have been claimed among lower animals and shows that in these cases we have to deal only with erroneous anthropomorphic interpretations of simple mechanical effects of stimuli. Hence the author comes to the conclusion that consciousness exists only in certain species of animals and in these only after a certain stage of development has been reached. This view is opposed to the theory that consciousness is already present in the egg and develops together with the egg and increases with progress of its development. Professor Loeb ignores the facts of subconscious feelings and does not consider the theory that there are conditions of subjectivity in the atoms which are analogous to the consciousness of man. The subjectivity in lower

animals is mere irritability; it develops into sentiency, and then in higher animals into consciousness by what Professor Loeb calls associative memory, and is perfected in the self-consciousness of man. This by the way Professor Loeb holds is only possible from the time when a definite mechanism contained in the central nervous system, viz., the mechanism for associative memory, is fully developed, and that before this time no associative memory and hence no consciousness is possible. The sudden origin of consciousness need not surprise us as we see the same thing in the development of every other function. The heart beat is not contained in the ovum, and it is not developed gradually with the development of the egg but it appears after the heart is formed and after the heart has reached a certain structural development. The power of optical perception of space is a function of a certain form of eyes. Only such animals as have these eyes are capable of visual perception of space and even in those animals this power is not yet present in the ovum but only appears after the eye has reached a certain stage of structural development. What is true for the eye and its functions is true for that mechanism which Professor Loeb calls associative memory, without which consciousness is impossible.

The contents of the book are contained in nineteen chapters whose titles are as follows:

Ueber einige Grundbegriffe und Grundthatsachen der vergleichenden Gehirnphysiologie.—Ueber das Nervensystem der Medusen und über Automatie und Coordination.—Das Centralnervensystem der Ascidien und die Bedeutung desselben für Reflexe.—Versuche an Aktinien.—Versuche an Echinodermen.—Versuche über die Gehirnphysiologie der Würmer.—Versuche über die Gehirnphysiologie der Arthropoden.—Versuche an Mollusken.—Die Segmentaltheorie bei Wirbelthieren.—Halbkreuzungen, associirte Stellungsänderungen der Extremitäten und Zwangsbewegungen.—Beziehungen zwischen der Orientirung und Function gewisser Elemente der segmentalen Ganglien.—Versuche am Kleinhirn.—Zur Theorie der thierischen Instincte.—Centralnervensystem und Vererbung.—Kriterien für die Constatirung von Bewusstsein bei niederen Thieren.—Gehirn und Bewusstsein.—Centrentheorie (Functionslocalisation) und Segmentaltheorie im Grosshirn.—Theilseelentheorie und Localisation einzelner Erinnerungsbilder.—Ueber einige Angriffspunkte für eine künftige Mechanik der Gehirnthätigkeit.

DIE GEISTIGEN UND SOCIALEN STRÖMUNGEN DES NEUNZEHNTEN JAHRHUNDERTS. By *Dr. Theobald Ziegler*. Berlin: Georg Bondi. 1899. Pages, 714.

This volume gives us a synopsis of the history of thought in Germany during the nineteenth century. Beginning with 1800 and having sketched the three world-views that were then struggling for supremacy, viz,, the éclaircissiment, classicism and romanticism, the author characterises Schelling's nature-philosophy and Hegel's phenomenology, which came to be the predominant systems of the first